8 Steamers

Introduction

Commercial steamers provide an easy, fast way to prepare large quantities of food. Steaming offers good nutrient retention, short cook times, and ease of preparation; little attention is needed from the chef, food can be cooked and served in the same pan, and cleanup is simple. Steamers are versatile appliances that can be used to prepare almost any food that does not require a crust. Delicate vegetables such as asparagus and broccoli are cooked without damage, frozen foods are defrosted and cooked in one step, and hard-to-cook meats such as beef ribs can be par-cooked more quickly and with less weight loss than oven roasting.

Figure 8-1. Two-compartment convection steamer on self-contained base.
Photo: Fisher-Nickel, inc.

In appearance, the compartment steamer resembles an oven. The cavity is typically rectangular on atmospheric steamers, and may be oval or round on pressure steamers. The door is “gasketed” and windowless. Controls are front-mounted. Figure 8-1 shows a typical two-compartment steamer atop a boiler base.

Steamers come in a variety of configurations, including countertop models, wall-mounted models and floor models mounted on a stand, pedestal or cabinet-style base. A steamer may consist of one to four stacked cavities. The cavity is usually designed to accommodate a standard 12 by 20-inch (300 mm x 500 mm) hotel pan. Smaller steamers may be designed for use with one-third size pans, and some large steamers can hold several 18 by 26-inch (460 mm x 660 mm) baking trays.

The steam itself can be produced several ways. Many compartment steamers have an external (with respect to the cooking compartment) electric, gas, or service-steam powered boiler that produces potable steam under pressure. This pressurized steam is delivered to the cooking compartment as demanded by the control settings. However, in the case of a pressureless steamer (see Figure 8-1), the compartment is openly connected to a condensate drain and the steam environment within the compartment cannot sustain a pressure above atmospheric (both raw steam and condensate exit the cooking cavity through this drain). In the case of a pressure steamer, only condensate is allowed to drain. Thus the cooking cavity is allowed to build up to the operating pressure of the boiler. In the larger boiler-based designs, there may be additional steam capacity (referred to as a power-take-off or PTO) to power other appliances such as a steam-jacketed kettles installed along side the steamer.

Steam also may be produced by a steam generator located within (or directly connected to) the cooking cavity. This method differs from the boiler-based steamers in that the steam is produced at (or slightly above) the compartment operating pressure (i.e., atmospheric pressure). This strategy is not used for pressure steamers.

A steamer may produce steam by boiling water poured directly into the cooking compartment prior to operation (this is the simplest form of an internal steam generator, typically referred to as a “connectionless” steamer). Heating elements are located either beneath the compartment’s floor or placed directly in the bottom of the compartment. Gas burners, placed below the compartment, may produce steam in the same fashion.

Steam may be supplied from an external source (e.g., centralized building steam). If this steam is clean, it can be routed directly to the steamer compartments. Otherwise, it can be run through a heat exchanger and used to generate potable steam from clean water.

Boiler-based and conventional steam-generator type steamers require a drain line, water line, and a connection to an energy source—typically gas or electricity. Self-contained units typically have boilers that fill automatically. Condensate from the cavity is directed to a drain tube, where it is cooled by a stream of water before flowing into the sewer (In many areas it is against code to drain water above 140°F). The new generation of “connectionless” steamers require no such connections beyond the electrical (or gas) hook up. Water is poured into the bottom of the cooking compartment and periodically refilled during the course of operation. When operation is suspended, the water is drained from the cavity into a pan or bucket.

Cooking Process

Steam cooking exploits the latent energy that steam at 212°F (100°C) carries, which is six times greater than water at the same temperature. When steam condenses on the surface of cold food, it transfers this latent energy to the food. If the pressure inside the steamer compartment rises, the steam can reach higher temperatures and deliver more energy to the food. This is the mechanism behind pressurized steamers, which may cook food faster than pressureless (atmospheric) steamers.

As with baking, a layer of insulating vapor can form around food in a still steamer cavity. The natural convection inside the cavity tends to strip away this insulating layer of air, but it has a limited ability to do so. If food is tightly packed, or if the steamer is fully loaded with pans, convection is impeded and cooking slows down. The last few years have seen the addition of a fan to some steamers. Forced convection in a steamer (e.g., via steam being injected from the boiler) has the same effect as it does in a convection oven, namely stripping away the insulating layer of vapor around the food to speed cooking and provide even heat throughout the steamer cavity.

Types of Steamers

There are two basic categories of steamers on the market, pressureless (atmospheric) and pressurized. Each type is available in gas, electric and direct-steam models.

Pressureless Steamer

Pressureless steamers, also commonly referred to as "atmospheric" steamers, maintain the cooking compartment at close to atmospheric pressure (between 0 and 2.9 psig (0 and 20 kPa)). They generally employ a large cooking cavity to facilitate the circulation of steam around the food product. Because these steamers operate at or near atmospheric pressure, the door may be safely opened at any point during the cooking cycle to check the product. Many atmospheric steamers employ a fan for forced convection steaming, to produce shorter cook times and even cooking throughout the compartment under full-load conditions.

Figure 8-2.
Two-compartment pressure steamer.
Photo: Fisher-Nickel, inc.

Pressure Steamer

Pressure steamers employ a closed system to allow the steam to build pressure inside the cooking compartment. These steamers are easily identifiable by their smaller compartments and heavy locking doors (see Figure 8-2). Although these steamers may cook smaller batches of food than pressureless steamers, cook times can be shorter, and energy efficiency higher, depending on the food product.

Low-pressure steamers typically operate between 3 and 9 psig (20 and 62 kPa). These are high-volume steamers that are often used in schools and hospitals. High-pressure steamers generally have smaller compartments and operate at 10-15psig (70-105 kPa). Although they hold less food, they may cook up to twice as fast as a low-pressure steamer. Pressure steamers require precise cook times because the food product cannot be checked while the steamer is operating.

Advanced Steamer Technologies

Pressureless steamers vary in their technological complexity. In addition to the three primary designs (boiler, steam-generator, and connectionless), manufacturers have employed different strategies for improving performance and reducing energy consumption. These emerging technologies include convection, vacuum pumps, close-system design, connectionless designs, compartment insulation and a stand-by mode.

Convection. Turbulent steam strips away the insulating layer next to the food, for faster cooking that is more even throughout the cavity. There are two basic methods of producing this forced convection. Some manufacturers inject steam into the cavity through jets in the cavity wall, while others use a fan to circulate the steam within the compartment.

Vacuum Pumps. Vacuum pumps have been used to reduce the pressure within the cooking compartment and lower the cooking temperature. This technology is promoted to reduce cook times and be gentler on delicate food products.

Closed System. One manufacturer employs a unique steam-control system that monitors pressure fluctuations within the cooking compartment, which reflects how much steam is being condensed on the food during the cooking process. As pressure builds in the compartment and less steam condenses, the unit's steam generator will suspend steam production. Only when the compartment pressure lowers, indicating that the food has absorbed heat from the steam, will the steam-generator reactivate.

Figure 8-3.
Connectionless steamer*.*
Photo: Stellar Steam.

Connectionless Design. "Connectionless" steamers have a water reservoir in the bottom of the cooking compartment in lieu of a water connection. The reservoir is manually filled and drained. Connectionless steamers have an advantage in that no steam leaves the cooking cavity during operation (except through a compartment vent). Thus, steam that does not condense on the food remains within the cavity, thereby significantly improving the steamer's energy performance. This strategy also mitigates some of the difficulties associated with boiler maintenance, and allows easier access for cleaning. Figure 8-3 shows a typical connectionless steamer. One manufacturer of a connectionless steamer incorporates a vacuum that reduces the temperature of steam (below 212°F) to provide a more "gentle" cooking event.

Compartment Insulation. Improved insulation around the cooking compartment reduces heat loss to the kitchen and can have a significant effect on standby (idle) energy consumption.

Standby Mode. Some manufacturers maintain a steam generator stand-by temperature just below boiling (typically, 180 to 200°F). This allows the appliance to produce steam 10-30 seconds after the steamer is loaded with food product and is a practical alternative to turning the steamer off between uses. Cook times may be slightly longer than if the steamer had been held at full input, as the cavity also absorbs heat. The increase in cook time depends on when the steamer was last used (leaving residual heat in the walls of the cavity.)

Controls

Steamer manufacturers offer a wide range of control packages. Some units are equipped with only the necessary controls for operation: an on/off switch, water-refill light, and simple timer. Others have an array of features such as boiler temperature, high- and low-power modes, idle/hold modes and other energy-saving settings. Timers can also terminate the cooking process to ensure that food product is not over cooked. Boiler-based units may also incorporate maintenance-indicator lights and an automated boiler blow-down mechanism to cleanse the heating elements or burner tubes of scale and sediment.

Some steamers use compensating timers, which automate defrosting and cooking. As an example, consider a load of frozen fish being cooked in a steamer with a compensating timer. Cavity temperature is monitored, and the timer does not begin to count down until the compartment nears 212°F (100°C), a temperature that corresponds to the frozen food having mostly thawed. At this point, the timer-preset with the desired cook time for a thawed food product has "compensated" for the food's initial condition, whether it was frozen or thawed (as well as the cavity's initial condition, cold or preheated). In a pressure steamer, the drain valve would close at this point and pressurized cooking would begin. [1]

Steamer Performance

An ASTM Standard Test Method for Performance of Steam Cookers[2] developed by the Food Service Technology Center (FSTC) allows manufacturers and users to gauge steamer-cooking performance directly, and to evaluate steamer energy consumption as well. As hard data on steamers has expanded, it is apparent that certain technologies and designs yield better performance.

The ASTM method reports several parameters of steamer performance, including preheat energy and time, idle energy rate, and cooking-energy efficiency and production capacity under heavy- (full-load) and light-loading (single-pan) conditions with both green peas and red potatoes.

Preheat Energy and Time

Preheat energy and duration can be useful to food service operators for managing power demands, and knowing how quickly the steamer can be ready for operation.

Typical preheat times can be between 5 and 20 minutes. Longer preheat times can discourage operators from turning units off between loads. Cook times can also be adversely affected by the unit's need to reheat the cavity walls as well as cook the food product. Some boiler-based units utilize compensating timers to address the challenge of reheating the cold compartment. Connectionless steamers, however, do not suffer this dilemma as the compartment is continually exposed to steam produced by the boiling water in the cooking compartment. Table 8-1 summarizes typical preheat time and energy consumption for various types of steamers.

Table 8-1. Input Rate and Preheat Test Results for Different Steamers.[3]

	Elec 1	Elec 2	Gas 1	Gas 2
Energy Input Rate	26.3 kW	19.1 kW	254 kBtu/h	199 kBtu/h
Preheat Time				
Heat-Up Time (min)	12.8	6.3	6.7	6.9
Fill Time (min)	4.2	0.5	3.9	3.6
Preheat Energy Consumption	5.3 kWh	1.0 kWh	28.1 kBtu	22.8 kBtu

Idle Energy Rate

Steamers spend the majority of the operating time in an idle, or stand-by condition. The idle energy rate of a steamer provides a good indication of its overall energy consumption use. Even in a busy restaurant, steamers may be idle 75% of the time. Figure 8-4 illustrates the range of normalized idle rates for three-pan, single-compartment steamers.[3-14]

Frozen Green Pea Cooking-energy efficiency

Frozen green pea cooking-energy efficiency is determined by cooking a full load of frozen peas (8 pounds (3.6 kg) of peas per pan) from a temperature of 0 ± 5°F to 180°F. Frozen green peas are representative of a typical frozen food product found on restaurant menus. As a test product, green peas are consistent in quality and readily available. More importantly, they yield consistent testing results that in turn provide reliable energy efficiency data.

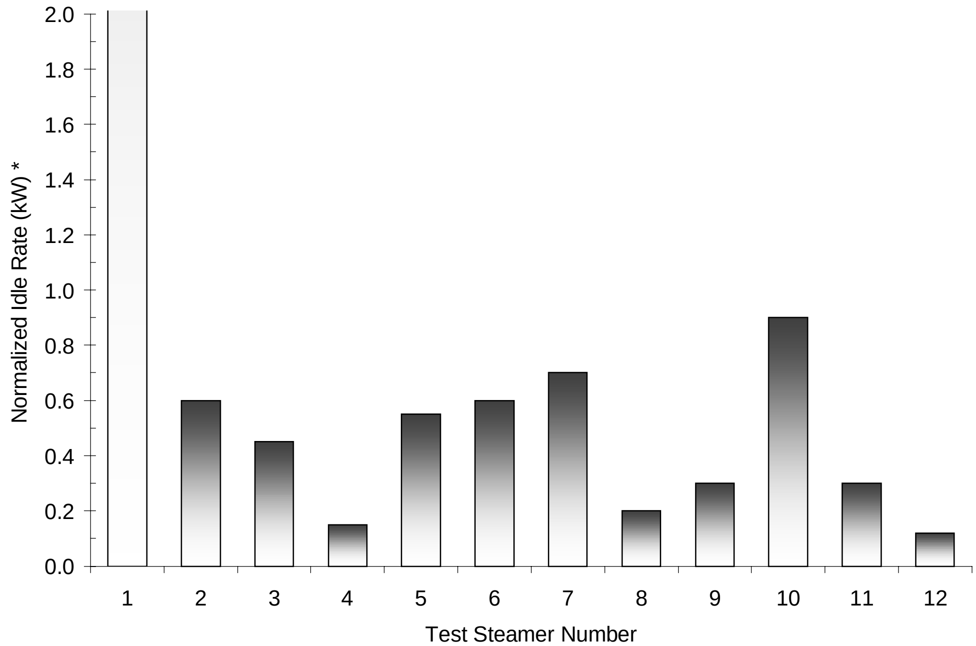

Figure 8-4.
Normalized electric pressureless steamer idle energy rates.

*Idle rates are normalized for 3-pan steamers.

Red Potato Cooking-Energy Efficiency

Red potato cooking-energy efficiency is determined by cooking a full load of red potatoes (8 pounds (3.6 kg) per pan) from room temperature (75 ± 5°F) to 195°F. As a tough-to-cook food product, red potatoes challenge the production capacity of a steamer more so than frozen green peas. With a low surface to volume ratio and a slower rate of condensation, potato-cooking tests can reveal far greater differences in cooking-energy efficiency between one steamer and another. In particular, the benefit of pressure steaming over atmospheric steaming becomes quite apparent when comparing red potato cooking energy efficiencies. Figures 8-5 and 8-6 compare the green pea and red potato cooking energy efficiencies for different types of steamers.[12-17]

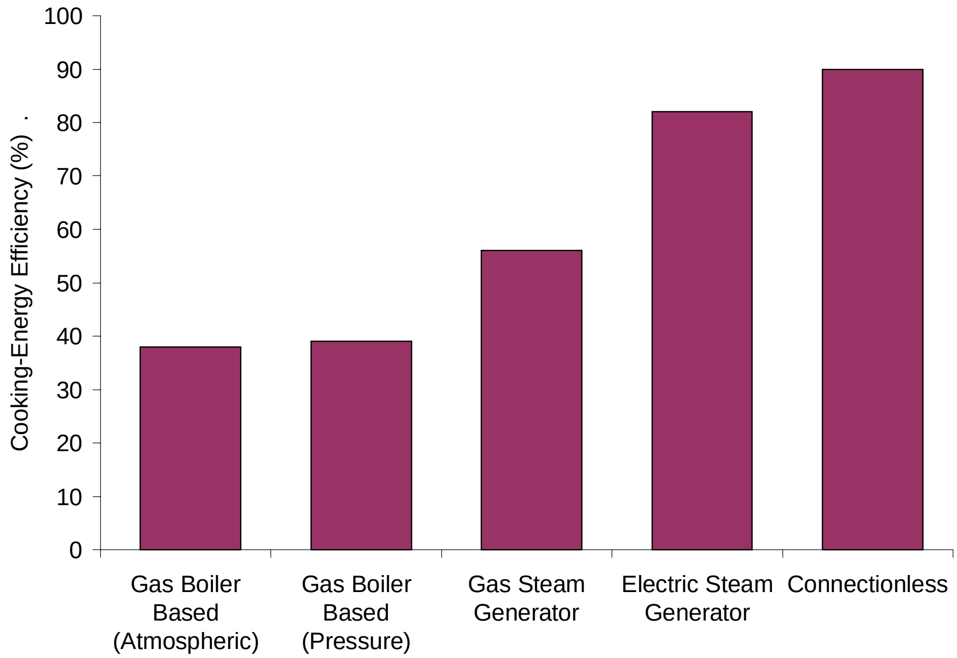

Figure 8-5.

Typical frozen green pea cooking-energy efficiencies of steamers.

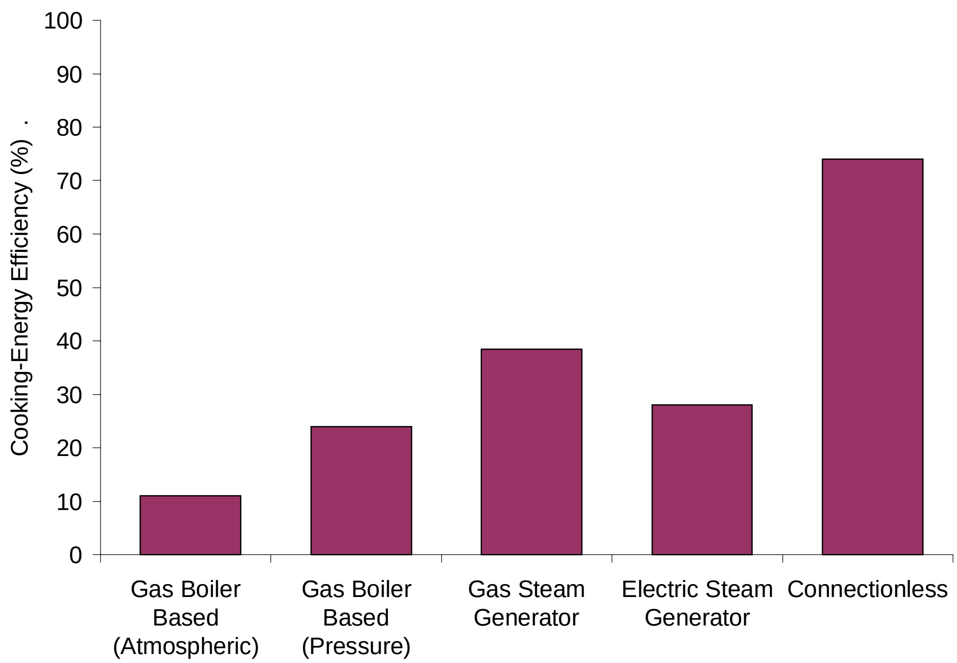

Figure 8-6.

Typical red potato cooking-energy efficiencies of steamers.

Frozen Green Pea and Whole Potato Production Capacities

Production capacity is the amount of food that can be cooked in a steamer in a given time. This figure is typically presented in product literature as the number of pounds of frozen vegetables that can be cooked per hour. Potatoes are a more stubborn food product and tend towards longer cook times than frozen peas. Figure 8-7 compares the frozen green pea production capacity for various electric pressureless steamers.[3-14]

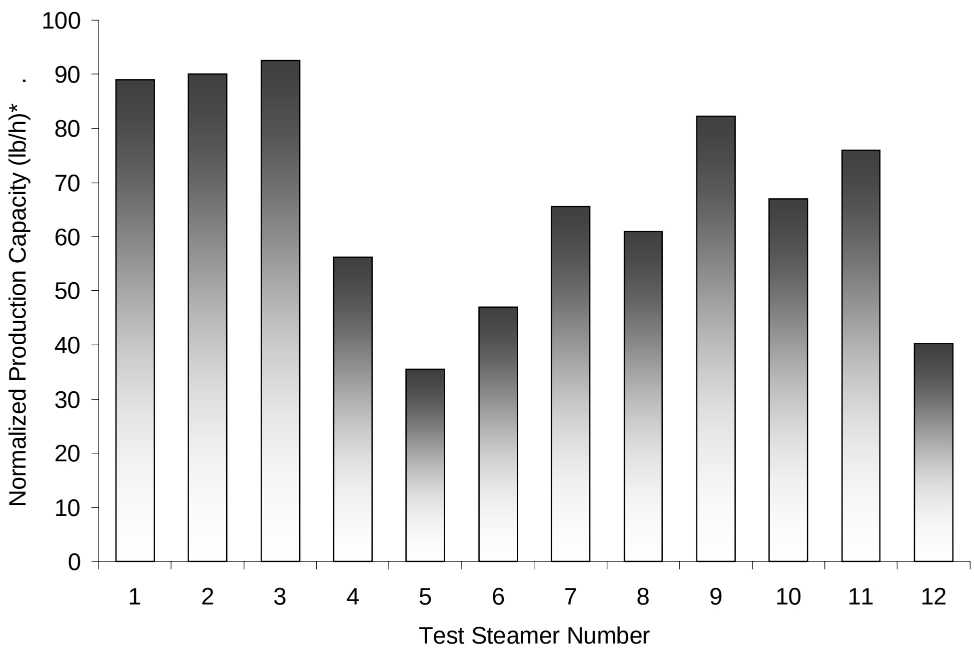

Figure 8-7.
Normalized electric pressureless steamer production capacity.

*Production capacity is normalized for 3-pan steamers.

Water Consumption and Condensate Temperature

Water consumption is monitored during both green pea and red potato cooking-energy efficiency tests to determine the rate of water usage. Water consumption characterization is useful for estimating water and sewage costs associated with appliance operation.[3]

Condensate temperature is monitored during both cooking-energy efficiency tests. Measurement of condensate temperature is useful to verify that the temperature does not exceed regional building code limits.[3]

Heavy-Load vs. Light-Load Efficiencies

The ASTM test method specifies different loading scenarios for heavy-load (full-compartment) and light-load (single-pan) tests. The heavy-load tests represent a steamer's maximum performance. The cooking compartment is filled to capacity with food product and the steamer exhibits its peak efficiency during these tests.

Light-load cooking-energy efficiency serves to ease comparisons between units of differing maximum compartment capacities. The cooking scenario also illuminates the wide disparity between steamers of differing cooking technologies. For example, boiler-based atmospheric steamers tasked with cooking a single pan of red potatoes can exhibit cooking energy efficiencies as low as 3%. Connectionless units typically exhibit cooking energy efficiencies of 30% or more under similar loading conditions.

Benchmark Energy Performance

Pressureless steamers exhibit dramatic differences in energy-efficiency, primarily depending on how the steam is produced and/or introduced and then maintained within the cooking compartment. The first-generation boiler-based steamers continually forced steam into the cooking compartment, whether or not the unit was cooking. Additionally, the boilers themselves rarely incorporated any insulation. This led to cooking energy efficiencies in the 25 to 30% range (determined under the full-load potato testing conditions of ASTM F1484-99). Second-generation steamers employed an insulated compact steam-generator, which had significantly less heat loss than traditional boiler systems. The performance of these second-generation steamers still suffered from continuously supplying steam to the cooking compartment, leading to high idle energy consumption.

Both of these approaches use an open-system design in which any steam injected into the compartment that does not condense on the food escapes down the drain as unused steam. Cooling water is injected into the steamer drain line to condense the wasted steam before it is expelled to the main sewer line. This continuous flow of steam down the drain places a continuous demand on the boiler as cold water (to replenish the wasted steam) is added to the boiler.

Connectionless steamers do not need the water and drain connections typically associated with steam cookers. Water is manually poured into a reservoir at the bottom of the cooking compartment at the beginning of each day and as needed. Heating elements inside or underneath the reservoir create steam by simply boiling the water, which then fills the compartment during the cooking process. Connectionless steamers are inherently more energy efficient than boiler-based or conventional steam-generator type steamers since any steam that does not condense on the food remains in the cooking compartment. Connectionless steamers typically exhibit cooking energy efficiencies that exceed 50% (ASTM full-load potato test). Figure 8-8 compares the cooking-energy efficiency for several types of electric pressureless steamers. Note that steamers numbered 4 through 12 are connectionless.[3-14]

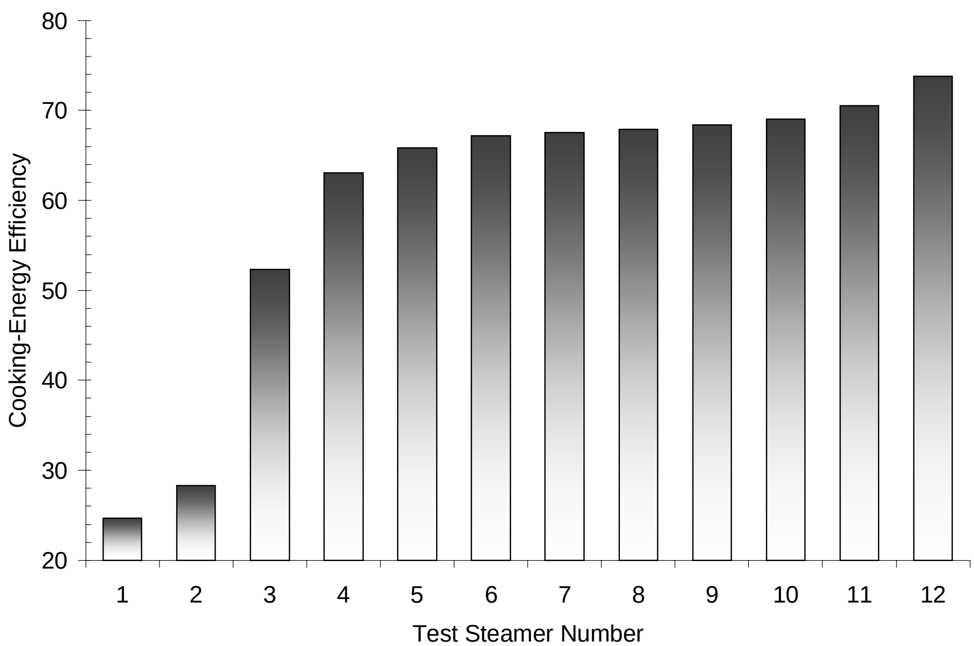

Figure 8-8.
Electric pressureless steamer cooking-energy efficiency.

Steamer Energy Consumption

Projected energy consumption for gas and electric steamers are presented in Table 8-2 and 8-3. Based on in-kitchen monitoring at the Pacific Gas and Electric Company Production-Test Kitchen in San Ramon, California, average energy consumption rates for steamers reflect a duty cycle of 15% for gas units and 20% for electric units.[18-22] Daily energy consumption for steamers was calculated by multiplying the median rated energy input for each steamer category by the respective duty cycle and the hours of operation. Duty cycle is defined as the average rate of energy consumption expressed as a percentage of the rated energy input or the peak rate at which an appliance can use energy. Typical operating hours were gleaned from in-kitchen energy-use monitoring experiences and observations as well as on the PREP study[23] and a proprietary end-use monitoring report. Projected annual energy consumption was determined by assuming a 6-day per week, 52-week per year operation.

Table 8-2. Projected Energy Consumption for Gas Steamers.

	Nominal Size	Rated Energy Input (kBtu/h)	Duty Cycle (%)	Avg. Energy Consumption (kBtu/h)	Typical Operating Hours (h/d) [a]	Annual Energy Consumption (kBtu) [b]
PRESSURE:						
Boiler-Based	6 pan	170 - 250				
(Median)		210	15 [c]	32	14	140,000
PRESSURELESS:						
Boiler-Based	6 pan	170 - 250				
(Median)		210	15 [c]	32	14	140,000

[a] Operating hours or appliance "on time" is the total period of time that an appliance is operated from the time it is turned "on" to the time it is turned "off".
[b] The annual energy consumption calculation is based on the average energy use rate x the typical operating hours x 6 days per week x 52 weeks per year.
[c] The duty cycle is based on monitoring two gas convection steamers with input rates of 250 kBtu/h and 200 kBtu/h in a real-world production kitchen. An associated average energy consumption rate of 32 kBtu/h was calculated.[18,19]

Table 8-3. Projected Energy Consumption for Electric Steamers.

	Nominal Size	Rated Energy Input (kW)	Duty Cycle (%)	Avg. Energy Consumption (kW)	Typical Operating Hours (h/d)[a]	Annual Energy Consumption (kWh)[b]	(kBtu)[c]
PRESSURE:							
Boiler-Based	6 pan	36 - 48					
(Median)		42	12 [d]	5	14	21,800	74,500
PRESSURELESS:							
Boiler-Based	6 pan	18 - 36					
(Median)		27	20 [d]	5	14	21,800	74,500
Connectionless	6 pan	12 - 24					
(Median)		18	14 [e]	2.5	14	10,920	37,300

[a] Operating hours or appliance "on time" is the total period of time that an appliance is operated from the time it is turned "on" to the time it is turned "off".
[b] The annual energy consumption calculation is based on the average energy use rate x the typical operating hours x 6 days per week x 52 weeks per year.
[c] Conversion Factor: 1kW = 3.413 kBtu/h.
[d] The duty cycle is based on monitoring two steamers in a real-world operation. [20,21]
[d] The duty cycle for connectionless steamers is based on monitoring two steamers in a real-world operation.[22]

A more robust energy model will be incorporated into subsequent revisions of the ASTM *Test Method for the Performance of Steam Cookers* (F1484). In this model, cooking energy use is broken down between heavy-and light-load conditions. Annual energy use is calculated based on preheat, idle, cooking energy rate, and production rate test results from applying ASTM F1484-99.

Ventilation Requirements

Steamers are classified as light duty from the perspective of exhaust ventilation. For a sidewall-canopy hood, the design ventilation rate for steam equipment would range from 150 to 200 cfm (75 to 100 L/s) per linear foot of hood.

Research and Development

Pressureless steamers have a large energy performance bandwidth, due to the inherent inefficiency of traditional boiler-based models and the efficient self-contained design of the new generation of connectionless steamers (Figure

8-7). Additionally, some of the electric connectionless steamers with high heavy-load cooking energy efficiencies demonstrate relatively high idle energy rates (steamer 10 in Figure 8-4). Since most steamers spend a significant amount of their operating time in idle, or stand-by mode, reducing idle losses would be a cost-effective way to reduce daily energy consumption. The option of a stand-by switch, where the temperature of the compartment "idles" below 212°F is one strategy. Increasing the level of insulation is another.

While steamers are seldom used for cook-to-order in most food service operations, the shorter cook times associated with boiler-based models gives them a perceived advantage over their connectionless counterparts. One strategy for reducing connectionless steamer cook times is to add a fan that circulates the steam throughout the compartment. By adding a convection component, these manufacturers hope to not only increase the production capacity of their models, but also hope to improve the cooking uniformity. However, more development is needed in this area to optimize the design and truly compete with the boiler-based models.

Manufacturers of compartment steamers have applied dramatic development efforts since the 1996 edition of this technology assessment, particularly in the area of electric counter-top models. However, there is distinct need for the development of gas-fired "connectionless" steamers that can raise the efficiency bar over conventional gas-fired boiler-based steamers.

Industry Market Focus

The latest generation of countertop-pressureless (atmospheric) steamers offer a significant improvement in energy efficiency and cooking performance, resulting in a lower operating cost. Pressureless steamers are available in compartment sizes ranging from 3 to 6 pans and may be stacked.

There are currently two types of high-efficiency pressureless steamers: connectionless and steam-generator. With respect to the connectionless variety, the absence of water and drain connections makes installation simple and lowers maintenance costs. The compartment is simply drained at the end of the day—no periodic de-liming is required. However, some connectionless steamers exhibit somewhat longer cook times than their steam-generator counterparts.

New steam-generator designs employ more of a closed system, which strive to provide steam to the cavity only as it is needed. One advantage of steam-generator type steamers is faster cook times and higher production rates—although steamer cook times are seldom a critical-path issue for most commercial kitchens. The latest generation of steam-generator type steamers uses less water and offers lower idle energy rates than their predecessors, allowing them to reasonably compete with their connectionless counterparts (Steamer number 3 in Figure 8-7).

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